LUNAR HALO OF JUNE 24-25, 1915, AT RICHMOND, VA.

June 24, 8:15 p. m.—An indistinct lunar halo was observed in very thin cirrus clouds and persisted until about 8:45 p. m. At 9 o'clock the vague outline of a 22°-halo was observed. The cirrus in which it appeared was then thin and fragmentary. These cirrus clouds gradually thickened until the sky became milky in appearance and the 22°-halo became very distinct. In addition two arcs were observed on either side of the moon at a distance of about 7° or 8°. These arcs were apparently portions of equal circles. Although the halo was brightest on its eastern edge no coloring was observed. The arcs were whitish in appearance and bore no resemblance to a corona. They faded about 10 p. m., and were not observed by me again. The halo was observed until about 11 p. m., at which time my view of it became obstructed.—*Thos. R. Brooks.*

9:25 p. m.—A pair of halos of concentric appearance was visible at 9:25 p. m., formed on cirri of very usual appearance, with some traces of striation from northeast to southwest. The larger of the halos was approximately 22° in radius, while the smaller one seemed to have a diameter equal to the radius of the larger. The color of both rings was of poor definition, and the only portion of chromatic distinctness was at the upper, zenithward, edge of the outer circle where a reddish hue could be detected on the inner side of the arc. A colorless paraselena, somewhat questionable, and of the shape of a luminous ear of corn, might be included in the description of the phenomenon. This was coincident with the righthand portion of the larger halo, and extended directly away from the moon.

Measurements could not be made instrumentally and the only check on size that the writer was able to establish was by comparison with estimated distances from the horizon to the lower edge and the zenith distance of the upper edge, which were 15° and 20°, respectively. The appearance at a later hour was not observed.—*C. G. Andrus.*

10:20 p. m.—An ordinary lunar halo of 22° with a distinct reddish tint on its inner side was observed at this time. The circle was nearly complete except for a small gap on its lower side. There was also at this time a well-defined corona but without pronounced colors. At 10:40 p. m. the halo was still visible.—*E. A. Evans.*

10:40 p. m. to 10:55 p. m.—When first seen the sky was practically clear, stars being visible outside of, but not within the outer circle, of which there were two. There were, however, some thin high clouds, but neither their form nor movement could be discerned with certainty. Occasionally light wisps, evidently much below the cirrus level, swept rapidly across the halo, but without taking on any iridescence or appearing in anyway to become involved with the halo.

The whole phenomenon consisted of an inner ring and an outer arc, the lower portion of which—that is, the part nearest the horizon—being missing. Both circle and arc were concentric. The general appearance of the phenomenon was a trifle lacking in definition. The disk of the moon was not sharply discernible and the outer and inner edges of the arc were somewhat blurred; especially was this true of the outer, which faded at a distance of about 1 degree from the reddish inner edge. The tint lining the arc was brightest above and to the left of the moon and there may have been a faint paraselena at that place, but its presence is doubtful in the mind of the observer. Presumably this was an ordinary halo of 22°, but from a rough approximation made by carefully sighting over a pencil and afterwards constructing the angle it appeared to have been slightly less. The inner circle measured in the same way and with as much accuracy as possible under the circumstances was considered to have been one of 9° radius and the band to have been ½° wide. This, excepting of course the moon, was the most pronounced feature of the display. Both inside and outside edges of the circle were reasonably clear cut and the circle was complete and of silvery whiteness. The whole phenomenon reached its full development at or before the time I first observed it at 10:40 p. m.; at least shortly after that time it began to dissipate, since at 10:55 p. m. only the outer arc, somewhat more blurred than before, was to be seen. At 1:00 a. m. of the 25th the large arc was again seen, this time through small wisps of clouds, possibly of the alto-cumulus or high stratocumulus type.—*J. H. Kimball.*

THE PENETRATING RADIATION PRESENT IN THE ATMOSPHERE.[1]

By A. GOCKEL.

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The author briefly reviews the results obtained by other workers up to the present time, in various localities, under water, above water and ground, and at considerable heights in the atmosphere. The question of instrumental errors is taken up; the effects of changes of temperature and of humidity and of variations in barometric pressure are also considered. The author also avails himself of existing data, and those obtained from his own researches, in the endeavor to ascertain whether or not there are regular daily and also seasonal variations in the penetrating radiation. Experiments have been carried out by the author, with the aid of Wulf's "Strahler," as well as with an arrangement devised by himself, using Benndorf's electrometer (registration instrument). Measurements have been carried out at the Bodensee by balloons, above the ice of the Eiger and Grindelwald glaciers; on the Aletsch glacier, on the Eggishorn, on the snow of the Jungfrau ridge, in ice grottoes, as well as near the bare rocks; also in the propinquity of grass land and gardens in Freiburg in Switzerland, together with other places. A few only of the results can be given here. The figures denote the production of ions per cubic centimeter per second. At the Bodensee, November 12, 1913—at 1 meter above water, 13.3; at 2 meters under water, 12.7; at 4 meters, 11.6; and at 6 meters, 10.6. In a garden at Freiburg, above the turf, 11.3 (dates not given); on the Aletsch glacier, at 2,800 meters, 10.7; near the gneiss rocks of the Trugberg, 19.6; and by the mica schist on the Eggishorn, 2,200 meters, 16.8. The strongest radiation observed by the author was that in the Lötschberg tunnel, through the granite, where the measurement gave 30 ions per cubic centimeter per second.

From his investigations the author draws the following deductions: (1) A depth of water of 3.5 meters is insufficient to absorb the radiation (cosmic?) coming from the atmosphere. (2) The observations on glaciers, as also with balloon ascents, show that there is an increase of the penetrating radiation with the height. (3) From solid crystalline rocks radiation is more intense than from cultivated alluvial soil. (4) A daily oscillation of the penetrating radiation is not noticeable in

[1] Phys. Zeits., Oct. 1, 1915, 16: 345-352.

Freiburg. (5) That portion of the radiation which comes from the earth is stronger in the warm season than in the cold. (6) The radiation coming from the atmosphere at a height over 2,200 meters shows an oscillation from day to day. Further observations on mountain tops are desirable in this connection.

It has been supposed—owing to the fact that at low elevations the production of ions is small while at great height the production is so large—that the sun is the direct source of the radiation. Against this theory is the lack of variation between day and night. It would be of interest to see how the radiation is affected during sun-spot periods and whether it is measurably influenced by the declination of the sun. On the Atlantic Ocean at a distance from the land a sensible local and temporary oscillation has been noticed to accord with that of the barometer. Lower pressure seems to favor an increase in the radiation. Again, upon approaching the land, a stronger radiation has been observed and there appears to be an oscillation corresponding daily with the periods during which the land and sea breezes prevail. These facts militate against the view that the sun is the immediate source of the penetrating radiation.—*E. O. W[alker]*.

CONCOMITANT CHANGES IN TERRESTRIAL MAGNETISM AND SOLAR RADIATION.[1]

By L. A. BAUER.

[Dated: Department of terrestrial magnetism, Washington, Nov. 17–Dec. 3, 1915.]

While good progress has been made by various investigators in establishing the relationship between fluctuations of the earth's magnetism and those of the sun's activity during the sun-spot cycle, there are still outstanding a number of important questions. The magnetic quantity hitherto generally used—as, for example, one of the magnetic elements (chiefly the magnetic declination) of the range of the diurnal variation (again chiefly of the magnetic declination)—has not admitted always of direct physical interpretation, nor has it furnished always a convenient measure of the magnetic changes. Accordingly the author in a preliminary examination of this relationship, made in 1909, introduced a quantity called the "local magnetic constant," designated by G, which, under certain assumptions, is proportional to the magnetic moment of the earth or to the intensity of magnetization.

Various recent investigations have shown that the quantity G provides an adequate measure of certain changes to which the earth's magnetism is continually subject. One interesting result of the 1909 investigation was that increased solar activity, as measured by sun-spot frequencies, was accompanied apparently by a decrease in the earth's magnetic constant. This is the general effect that accompanies any large magnetic disturbance. For example, during the magnetic storm of September 25, 1909, the earth's magnetic state was below normal for a period of about 3 months. Since magnetic storms in general increase in frequency, as well as in magnitude, with increased sun-spot activity, the general effect on the magnetic constant during the sun-spot cycle is as it was found to be.

In the present paper there are considered changes in the earth's magnetism of a considerably minor order of magnitude as compared with the magnetic perturbations just discussed; however, they are found to be not less important. The precise relationship between changes in solar radiation and possible changes in the earth's magnetism could be subjected to a definite examination only when values of the solar constant, of such accuracy as those of the Smithsonian Institution, became available. Fortunately we now have a series of determinations at Mount Wilson, of this constant by Abbot for a period of four to five months during the years 1905–1914, excepting 1907. The 1913 and 1914 data were kindly supplied by him in advance of publication, for special use in connection with the present investigation. There were likewise made available the magnetic data for the same years, recorded at the observatories of the Coast and Geodetic Survey, for which acknowledgment should be made to the superintendent of that survey.

In the Balfour-Schuster theory of the diurnal variation of the earth's magnetism, it was necessary to introduce an additional hypothesis to account for the great ionization required by the theory, and solar radiation suggested itself as a possible cause. "Hence," Schuster says, "we might expect an increased conducting power in summer and in daytime as compared with that found during winter and at night." If solar radiation plays the prominent part required in the Schuster analysis of the diurnal variation of the earth's magnetism, the question naturally arises: If, at any particular moment or period, the solar radiation falling upon the earth's atmosphere suffers from some cause an appreciable increase or decrease, is there a corresponding observable magnetic change? A diminution, for example, in the amount of solar radiation could be caused by the interposition of some screening body between the sun and the earth. The interposing body might be the moon, as during a total solar eclipse, or a cooling layer above the sun's photosphere. In the first case magnetic observations made during a total solar eclipse would shed some light, and in the second case a comparison of observed values of the solar constant with concomitant magnetic records would be of great interest. We have carried out both lines of inquiry.

It is not possible to enter here into the details of all tests applied and as to methods of computation employed. It must suffice to state the chief conclusions derived to date:

a. Changes in the earth's magnetism of appreciable amount are found associated with the changes in solar radiation as shown by values of the solar constant possessing the requisite accuracy. For the average daily change in the solar constant, which amounts to about 1.5 per cent of its value, the magnetic constant used as a measure of the prevailing magnetic state of the earth suffers a change of about 0.003 per cent, or about one digit in the fifth decimal C. G. S. units. The effect on the horizontal component of the earth's magnetic force would be about twice this.

b. Decreased solar constant appears to be accompanied by increased magnetic constant and decreased diurnal range of the earth's magnetism, in accordance with the following relations: 1 per cent change in the solar constant is accompanied by a change of about 0.002 per cent in the magnetic constant and by about 1 per cent in the magnetic diurnal range. Assuming for the present a linear relation between the solar constant and magnetic changes, a 10 per cent change in the solar constant, as occasionally occurs, may be accompanied by a change in the magnetic constant of about 0.002 per cent and by about 10 per cent in the magnetic diurnal range. The magnetic effects observed during total solar eclipses are about equivalent to those which might be expected from

[1] *Reprinted from* Proc., Natl. acad. sci., Washington, Jan. 1916, 2: 24–27.